

System for Analysis of Fabric Surface

Background to the Invention

5 1. Field of the Invention

The invention relates to a system for the analysis of fabric surface appearance, and in particular to a method and apparatus for constructing a three-dimensional image of 10 a fabric surface.

2. Background Information

When assessing the grade of fabric it is desirable to use 15 objective evaluation criteria so that interested parties can be confident in the represented grading. Recent progress in this area has been directed towards developing automated analysis techniques which are effective in identifying surface characteristics, such as pilling, of 20 fabric. Such automated techniques can provide a standard, objective, evaluation of fabric grade.

Current automated techniques include acquiring surface images from a fabric specimen using a Charge-Coupled Device

(CCD) camera with a suitable lighting source. The camera obtains an image of the fabric surface which is manipulated to identify the different reflex intensity (gray) areas created by pilling and background features. A suitable 5 grey threshold is applied to identify pilling on the fabric surface. Such a technique suffers from the disadvantage of the reflectance not being consistent across patterned, colourful or multicoloured fabrics. The reflex intensity of the pilled areas appears different in different colour 10 areas of the fabric. Thus, on patterned fabric this technique cannot consistently identify fabric surface characteristics.

To avoid the above problem a laser triangulation technique 15 can be used. In this technique the fabric is placed on an X-Y translation table and the high spots on the fabric surface measured one by one with a laser sensor. However, data capture using this technique is considerably slower than with the CCD camera, and because the technique relies 20 on reflection of a laser beam the technique has limitations of use with dark fabrics.

Summary of the Invention

It is an object of the present invention to provide a system for the analysis of fabric surface appearance that 5 is unaffected by the colour or pattern of a fabric.

It is a further object of the present invention to provide a system for the analysis of fabric surface appearance that ameliorates the above-mentioned disadvantages or at least 10 provides the public with a useful alternative.

According to a first aspect of the invention there is provided a system for analysing fabric surface appearance including a feed mechanism for running a fabric over a 15 crest, an image capturing device operable to capture a plurality of profile images of the fabric surface at the crest, and a computer system in communication with the image capture device and operable to manipulate the images to produce a three-dimensional representation of the fabric 20 surface.

Preferably, the feed mechanism includes a frame for holding the fabric bent to form a crest, and a drive mechanism for moving the frame in a manner that moves the crest in the

fabric from one end of the fabric to the other. The frame may be an A-frame. Alternatively, the frame may include at least two rollers, an endless belt disposed between the two rollers, and a drive motor for rotating at least one of the 5 rollers, and wherein the belt has fasteners for removably securing the fabric to it.

Preferably, the image capturing device is a Charge-Coupled Device camera.

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According to a second aspect of the invention there is provided a method of analysing fabric surface appearance including the steps of: capturing a series of profile images of the surface of a fabric and manipulating the 15 images to produce a three-dimensional representation of the fabric surface, identifying prominent characteristics in the three-dimensional representation, and comparing the identified prominent characteristics to reference data to identify a grade for the fabric.

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Preferably, the images to produce a three-dimensional representation of the fabric surface includes: applying a threshold to each image to identify the profile edge line of the fabric surface, resolving the profile edge line into

data points, and combining the data points from the series of images to produce a three-dimensional map.

5 Preferably, identifying prominent characteristics in the three-dimensional representation includes: filtering the three-dimensional map, and identifying portions of the three-dimensional map with characteristics above a predetermined height.

10 Preferably, the reference data includes height, area and distribution density of the prominent characteristics.

According to a third aspect of the invention there is provided a system for analysing fabric surface appearance 15 including: a feed mechanism for running a fabric over a crest including, a frame for holding the fabric bent to form a crest, and a drive mechanism for moving the frame in a manner that moves the crest in the fabric from one end of the fabric to the other, an image capturing device operable 20 to capture a plurality of profile images of the fabric surface at the crest, and a computer system in communication with the image capture device and operable to manipulate the images to produce a three-dimensional representation of the fabric surface, to identify prominent

characteristics in the three-dimensional representation, and to compare the identified prominent characteristics to reference data to identify a grade for the fabric.

- 5 Further aspects of the invention will become apparent from the following description, which is given by way of example only.

Brief Description of the Drawings

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Embodiments of the invention will now be described with reference to the accompanying drawings in which:

15 Figure 1 illustrates a set of apparatus according to the invention,

Figure 2 illustrates steps for analysing fabric surface appearance according to the invention, and

20 Figure 3 illustrates an embodiment of a feed mechanism for running a fabric over a crest.

Description of the Preferred Embodiments

- Figure 1 illustrates a schematic of a preferred apparatus set-up of the invention. A CCD camera 3 faces a white background 1. In the preferred embodiment the white background 1 is a light box. For reference the centre of the image captured by the CCD camera 3 falls on a path marked by the dashed line 6.
- Disposed between the camera 3 and background 1 is a fabric sample 2 bend to a substantially "A" shape to provide an upper crest 5 which lies on line 6 in the centre of the image captured by CCD camera 3.
- A computer system 4 is in communication to receive the captured images from CCD camera 3. The computer system 4 manipulates and analyses the images captured by the CCD camera 3. This is described in detail later in this description.

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According to the above arrangement the CCD camera 3 captures a profile image of the fabric surface at Crest 5. Illuminated background 1 provides a contrast to fabric 2 to aid computer manipulation of the image. Fabric 2 is

disposed on a frame mechanism (not shown in figure 1) operable to run the fabric 2 over crest 5. CCD camera 3 is interlocked with a drive means of the frame mechanism to capture a profile image from for a plurality of fabric 2 profiles as they pass over crest 5.

Figure 3 illustrates an embodiment of the frame mechanism. First and second rollers 13, 14 are rotatably disposed one above the other. An endless belt 15 is disposed about the 10 rollers 13,14. A drive means 16, preferably a stepper motor, is engaged to rotate roller 14 and thus endless belt 15. A plurality of fasteners 17 are provided to secure fabric sample 2 to endless belt 15. Operation of stepper motor 16 runs endless belt 15 and Fabric 2 over upper 15 roller 13, the upper portion of which forms crest 5.

Figure 2 illustrates process steps in the preferred embodiment of a method for analysing the fabric surface. The first step is image capture 7. The CCD camera 3 captures a profile image for each of a plurality of 20 portions of the fabric 2 surface as it passes over crest 5. The images are recorded by computer system 4.

The second step is image segmentation 8. The edge line of the fabric from each profile image is obtained. This is done by applying a histogram analysis and selecting a suitable threshold at which to segment the profile image.

- 5 There are two approximate normal distributions $(u_1, \sigma_1), (u_2, \sigma_2)$ in the image histogram. One is the gray distribution of the shadow region of the fabric 2, and the other is the no shadow region of the illuminated background 1. The threshold can be defined according to the equation

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$$t = \frac{u_1 + u_2 + 3\sigma_1 - 3\sigma_2}{2}$$

- The third step 9 is to extract the height profile of the fabric surface line by line. This is done by calculating the position (x_i, y_i) for each point i along the profile of the gray image, where x_i is the horizontal coordinate of each point i and y_i is the height coordinate of each point i . Thus, x, y data is obtained for the fabric profile at a plurality of positions along the fabric length.

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20 The fourth step 10 is to generate a three-dimensional representation of the fabric surface. This is done by combining all x, y surface data from the profile images obtained to produce a three dimensional surface map. Since the fabric sample is running passed the crest 5 the step

size between two successive profile images is a constant s which can be calculated from the stepper motor 16 speed. The two-dimensional coordinates system (x,y) of the profile images is mapped to a three dimensional coordinate system (x,y,z) based of the movement of the fabric sample running past crest 5. The Z coordinate is obtained from the distance of travel of the fabric sample between images. The first image captured by the CCD camera 3 is at pint $z = 0$ and the next z coordinates are $s, 2s, 3s$ and so on. The three-dimensional surface map of the fabric sample is produced by this sequence of three-dimensional (x,y,z) data.

Once the three-dimensional representation has been obtained the next step, 11, is to extract surface characteristics, such as pill features, from the three dimensional data. This is done by applying Gaussian filter to reduce noise and enhance the characteristic features of the three dimensional surface image. The three-dimensional surface image is then segmented into two separate portions, a characteristic portion and a background portion, based on height. The characteristic features are contained in the first, characteristic, portion. These might be all portions of the three dimensional image having height

values (y_i) above a value which is determined from the basic fabric weight. These features are analysed to determine such factors as their number, height, density and size. Typically the characteristic being analysed are 5 fabric pills.

The final step 12 is to compare the extracted characteristic features to reference data to identify a grade for the fabric.

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By use of profile images from a fabric sample the invention is immune to fabric characteristics such as colour and pattern.

15 Where in the foregoing description reference has been made to integers or elements having known equivalents then such are included as if individually set forth herein.

20 Embodiments of the invention have been described, however it is understood that variations, improvements or modifications can take place without departure from the spirit of the invention or scope of the appended claims.